AHDB1_Death_TS

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https://github.com/StatQuest/logistic_regression_demo/blob/master/logistic_regression_demo.R ###Read in main data files

```
library(multcomp)
library(ggplot2)
library(nlme)
library(grid)
library(gridExtra)
library(emmeans)
library(cowplot)
library(ggplot2)
```

Read in the data

```
data=read.csv("AHDB_MasterDataSheet.csv")
data
```

```
##    AgeCategory ID_Band Sex Treatment Died_InTrt Treatment_Category
## 1      Younger    4741   F         B          0               Heat
## 2      Younger    4703   F         B          0               Heat
## 3      Younger    4712   F         B          0               Heat
## 4      Younger    4787   M         B          0               Heat
## 5      Younger    4791   M         B          0               Heat
## 6      Younger    4783   M         B          0               Heat
## 7      Younger    4757   M         B          0               Heat
## 8        Older    4593   M         B          0               Heat
## 9        Older    4534   F         B          0               Heat
## 10     Younger    4792   F         B          0               Heat
## 11     Younger    4769   M         B          0               Heat
## 12       Older    4600   M         B          0               Heat
## 13       Older    4614   M         B          0               Heat
## 14     Younger    4816   M         B          0               Heat
## 15     Younger    4778   M         B          0               Heat
## 16     Younger    4797   F         B          0               Heat
## 17       Older    4613   M         B          0               Heat
## 18     Younger    4788   M         B          0               Heat
## 19       Older    4620   F         B          0               Heat
## 20     Younger    4771   M         B          0               Heat
```

```
## 21    Younger   4764  M        B        0              Heat
## 22    Younger   4725  M        B        0              Heat
## 23    Younger   4800  M        B        0              Heat
## 24    Younger   4803  M        B        0              Heat
## 25    Younger   4809  F        B        0              Heat
## 26    Younger   4804  M        B        0              Heat
## 27      Older   4531  F        B        1              Heat
## 28    Younger   4768  F        B        1              Heat
## 29    Younger   4761  F        B        1              Heat
## 30    Younger   4774  F        B        1              Heat
## 31    Younger   4802  F        B        1              Heat
## 32    Younger   4810  F        B        1              Heat
## 33    Younger   4817  F        B        1              Heat
## 34      Older   4529  F        C        0              Heat
## 35    Younger   4704  F        C        0              Heat
## 36      Older   4715  F        C        0              Heat
## 37      Older   4608  F        C        0              Heat
## 38      Older   4559  M        C        0              Heat
## 39    Younger   4782  F        C        0              Heat
## 40    Younger   4748  F        C        0              Heat
## 41    Younger   4717  F        C        0              Heat
## 42      Older   4561  F        C        0              Heat
## 43    Younger   4731  F        C        0              Heat
## 44      Older   4554  F        C        0              Heat
## 45      Older   4601  F        C        0              Heat
## 46    Younger   4814  F        C        0              Heat
## 47      Older   4586  F        C        0              Heat
## 48    Younger   4776  F        C        0              Heat
## 49    Younger   4805  F        C        0              Heat
## 50    Younger   4775  F        C        1              Heat
## 51    Younger   4737  F        C        1              Heat
## 52      Older   4530  F        D        0              Heat
## 53    Younger   4759  F        D        0              Heat
## 54      Older   4551  F        D        0              Heat
## 55    Younger   4749  F        D        0              Heat
## 56      Older   4573  F        D        0              Heat
## 57      Older   4578  F        D        0              Heat
## 58      Older   4604  F        D        0              Heat
## 59    Younger   4723  F        D        0              Heat
## 60    Younger   4735  F        D        0              Heat
## 61    Younger   4719  F        D        1              Heat
## 62      Older   4562  F        D        0              Heat
## 63    Younger   4729  F        D        0              Heat
## 64    Younger   4795  F        D        0              Heat
## 65      Older   4621  F        D        0              Heat
## 66    Younger   4773  F        D        0              Heat
## 67    Younger   4752  F        D        0              Heat
## 68    Younger   4765  F        D        0              Heat
## 69    Younger   4798  F        D        1              Heat
## 70    Younger   4739  F        E        0              Heat
## 71    Younger   4745  F        E        0              Heat
## 72    Younger   4785  F        E        0              Heat
## 73    Younger   4784  F        E        0              Heat
## 74    Younger   4758  F        E        0              Heat
```

```
## 75       Older    4533    F         E          0                Heat
## 76       Older    4579    F         E          0                Heat
## 77     Younger    4738    F         E          0                Heat
## 78     Younger    4582    F         E          0                Heat
## 79       Older    4535    F         E          0                Heat
## 80     Younger    4777    F         E          0                Heat
## 81     Younger    4720    F         E          0                Heat
## 82       Older    4612    F         E          0                Heat
## 83       Older    4548    F         E          0                Heat
## 84     Younger    4625    F         E          0                Heat
## 85       Older    4619    F         E          0                Heat
## 86     Younger    4772    F         E          0                Heat
## 87     Younger    4766    F         E          0                Heat
```

```
xtabs(~ Died_InTrt + Sex, data=data) # Summarize the number of deaths by Sex
```

```
##           Sex
## Died_InTrt  F  M
##          0 57 19
##          1 11  0
```

```
xtabs(~ Died_InTrt + AgeCategory, data=data) # Summarize the number of deaths by Age
```

```
##           AgeCategory
## Died_InTrt Older Younger
##          0    27      49
##          1     1      10
```

Run generalized linear model for Sex

```
logistic <- glm(Died_InTrt ~ Sex, data=data, family="binomial")
summary(logistic)
```

```
##
## Call:
## glm(formula = Died_InTrt ~ Sex, family = "binomial", data = data)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -0.59406  -0.59406  -0.59406  -0.00013   1.90872
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -1.6452     0.3293  -4.996 5.87e-07 ***
## SexM         -16.9209  1496.3960  -0.011    0.991
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
```

```
##
##     Null deviance: 66.043  on 86  degrees of freedom
## Residual deviance: 60.192  on 85  degrees of freedom
## AIC: 64.192
##
## Number of Fisher Scoring iterations: 17
```

```r
female.log.odds <- log(9 / 36)
female.log.odds
```

```
## [1] -1.386294
```

```r
male.log.odds <- log(0 / 18)
male.log.odds
```

```
## [1] -Inf
```

Now calculate the overall "Pseudo R-squared" and its p-value for Sex

```r
## NOTE: Since we are doing logistic regression...
## Null devaince = 2*(0 - LogLikelihood(null model))
##               = -2*LogLikihood(null model)
## Residual deviacne = 2*(0 - LogLikelihood(proposed model))
##                   = -2*LogLikelihood(proposed model)
ll.null <- logistic$null.deviance/-2
ll.proposed <- logistic$deviance/-2

## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null - ll.proposed) / ll.null
```

```
## [1] 0.08859916
```

```r
## chi-square value = 2*(LL(Proposed) - LL(Null))
## p-value = 1 - pchisq(chi-square value, df = 2-1)
1 - pchisq(2*(ll.proposed - ll.null), df=1)
```

```
## [1] 0.01556518
```

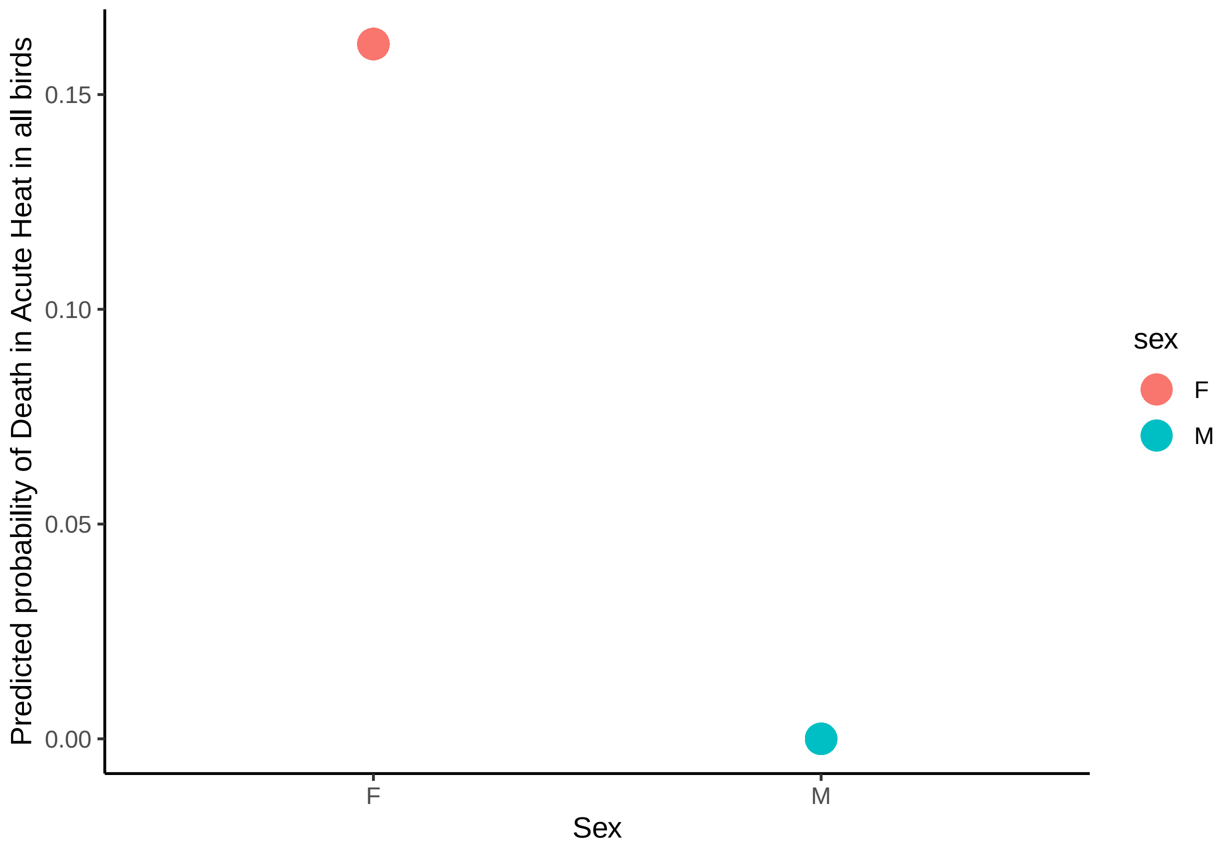
```r
1 - pchisq((logistic$null.deviance - logistic$deviance), df=1)
```

```
## [1] 0.01556518
```

Lastly, let's see what this logistic regression predicts, given that an individual is either female or male (and no other data about them).

```r
predicted.data_sex <- data.frame(
  probability.of.Data=logistic$fitted.values,
  sex=data$Sex)

## We can plot the data...
ggplot(data=predicted.data_sex, aes(x=sex, y=probability.of.Data)) +
  geom_point(aes(color=sex), size=5) +
  xlab("Sex") +
  ylab("Predicted probability of Death in Acute Heat in all birds") +
  theme_classic()
```




```r
## Since there are only two probabilities (one for females and one for males),
## we can use a table to summarize the predicted probabilities.
xtabs(~ probability.of.Data + sex, data=predicted.data_sex)
```

```
##                        sex
## probability.of.Data     F  M
##   8.64686924501238e-09  0 19
##   0.161764705882353    68  0
```

Run a generalized linear model for Age

```
logistic2 <- glm(Died_InTrt ~ AgeCategory, data=data, family="binomial")
summary(logistic2)
```

```
##
## Call:
## glm(formula = Died_InTrt ~ AgeCategory, family = "binomial",
##     data = data)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.6095  -0.6095  -0.6095  -0.2697   2.5816
##
## Coefficients:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -3.296      1.018  -3.236  0.00121 **
## AgeCategoryYounger   1.707      1.076   1.586  0.11267
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 66.043  on 86  degrees of freedom
## Residual deviance: 62.328  on 85  degrees of freedom
## AIC: 66.328
##
## Number of Fisher Scoring iterations: 6
```

Now calculate the overall "Pseudo R-squared" and its p-value for Age

```
## NOTE: Since we are doing logistic regression...
## Null devaince = 2*(0 - LogLikelihood(null model))
##               = -2*LogLikihood(null model)
## Residual deviacne = 2*(0 - LogLikelihood(proposed model))
##                   = -2*LogLikelihood(proposed model)
ll.null <- logistic2$null.deviance/-2
ll.proposed <- logistic2$deviance/-2

## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null - ll.proposed) / ll.null
```

```
## [1] 0.05625529
```

```
## chi-square value = 2*(LL(Proposed) - LL(Null))
## p-value = 1 - pchisq(chi-square value, df = 2-1)
1 - pchisq(2*(ll.proposed - ll.null), df=1)
```

```
## [1] 0.05391723
```

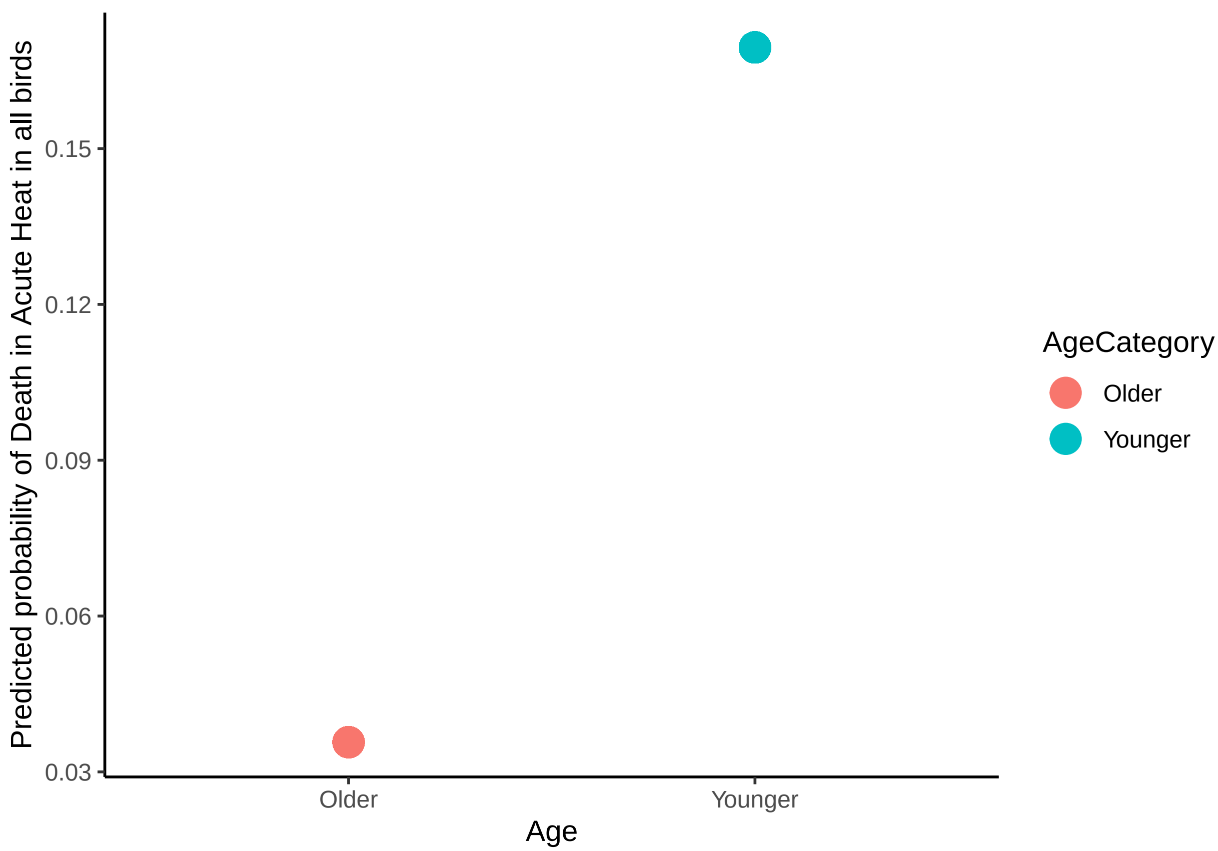
```
1 - pchisq((logistic2$null.deviance - logistic2$deviance), df=1)
```

```
## [1] 0.05391723
```

Lastly, let's see what this logistic regression predicts, given that an individual is either younger or older (and no other data about them).

```
predicted.data_Age <- data.frame(
  probability.of.Data=logistic2$fitted.values,
  AgeCategory=data$AgeCategory)

## We can plot the data...
ggplot(data=predicted.data_Age, aes(x=AgeCategory, y=probability.of.Data)) +
  geom_point(aes(color=AgeCategory), size=5) +
  xlab("Age") +
  ylab("Predicted probability of Death in Acute Heat in all birds") +
  theme_classic()
```



```r
## Since there are only two probabilities (one for females and one for males),
## we can use a table to summarize the predicted probabilities.
xtabs(~ probability.of.Data + AgeCategory, data=predicted.data_Age)
```

```
##                      AgeCategory
## probability.of.Data  Older Younger
##   0.0357142857142918    28       0
##   0.169491525423729      0      59
```

Run a generalized linear model for Sex and Age

```r
logistic_Age_Sex <- glm(Died_InTrt ~ AgeCategory + Sex, data=data, family="binomial")
summary(logistic_Age_Sex)
```

```
##
## Call:
## glm(formula = Died_InTrt ~ AgeCategory + Sex, family = "binomial",
##     data = data)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -0.70896  -0.70896  -0.29817  -0.00009   2.50419
##
## Coefficients:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)          -3.091      1.022  -3.023   0.0025 **
## AgeCategoryYounger    1.838      1.084   1.697   0.0898 .
## SexM                -17.999   2388.807  -0.008   0.9940
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 66.043  on 86  degrees of freedom
## Residual deviance: 55.900  on 84  degrees of freedom
## AIC: 61.9
##
## Number of Fisher Scoring iterations: 18
```

Now calculate the overall "Pseudo R-squared" and its p-value for sex and age

```r
## NOTE: Since we are doing logistic regression...
## Null devaince = 2*(0 - LogLikelihood(null model))
##               = -2*LogLikihood(null model)
## Residual deviacne = 2*(0 - LogLikelihood(proposed model))
##                   = -2*LogLikelihood(proposed model)
```

```r
ll.null <- logistic_Age_Sex$null.deviance/-2
ll.proposed <- logistic_Age_Sex$deviance/-2

## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null - ll.proposed) / ll.null
```

```
## [1] 0.1535734
```

```r
## chi-square value = 2*(LL(Proposed) - LL(Null))
## p-value = 1 - pchisq(chi-square value, df = 2-1)
1 - pchisq(2*(ll.proposed - ll.null), df=1)
```

```
## [1] 0.001448954
```

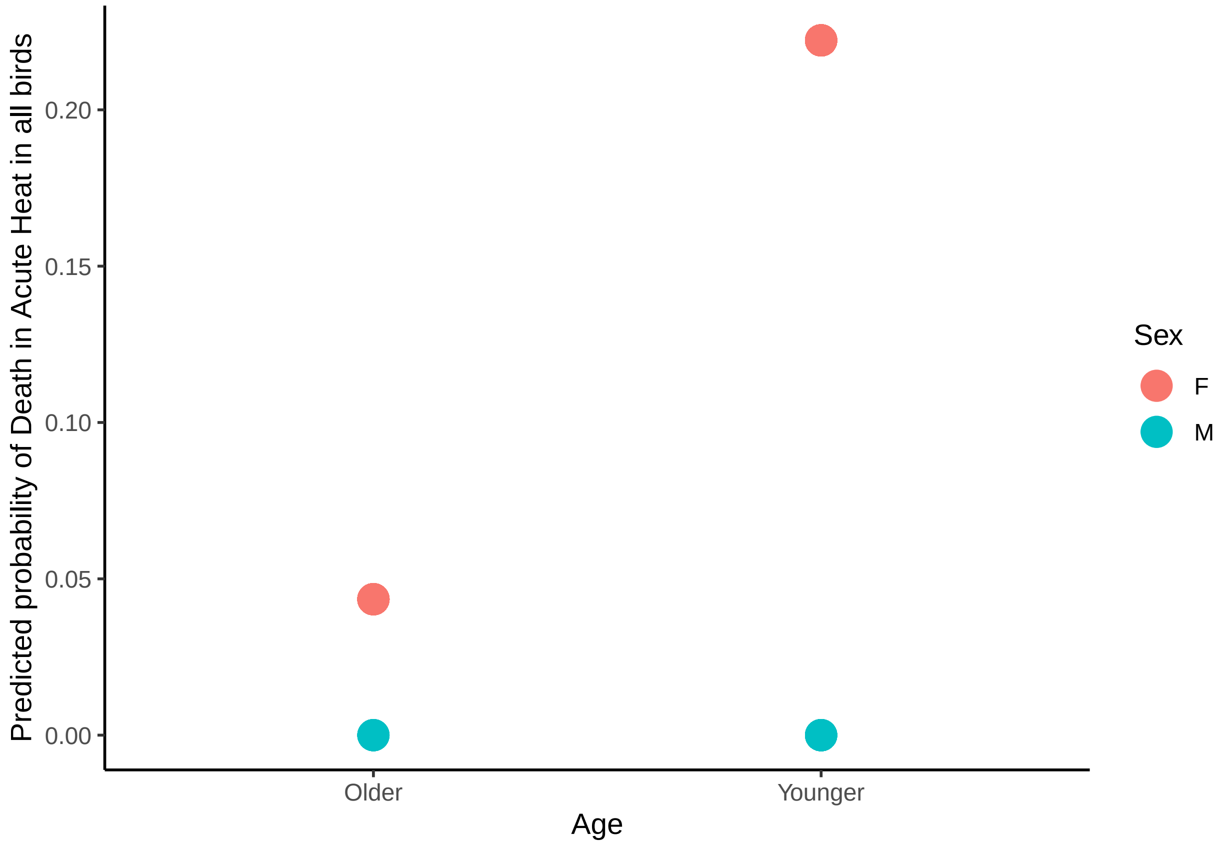
```r
1 - pchisq((logistic_Age_Sex$null.deviance - logistic_Age_Sex$deviance), df=1)
```

```
## [1] 0.001448954
```

Lastly, let's see what this logistic regression predicts, given that an individual is either younger female, older female, younger male, or older male (and no other data about them).

```r
predicted.data_Age_Sex <- data.frame(
  probability.of.Data=logistic_Age_Sex$fitted.values,
  AgeCategory=data$AgeCategory, Sex=data$Sex)

## We can plot the data...
ggplot(data=predicted.data_Age_Sex, aes(x=AgeCategory, y=probability.of.Data, fill=Sex)) +
  geom_point(aes(color=Sex), size=5) +
  xlab("Age") +
  ylab("Predicted probability of Death in Acute Heat in all birds") +
  theme_classic()
```




```
## Since there are only two probabilities (one for females and one for males),
## we can use a table to summarize the predicted probabilities.
xtabs(~ probability.of.Data + AgeCategory + Sex, data=predicted.data_Age_Sex)
```

```
## , , Sex = F
##
##                        AgeCategory
## probability.of.Data     Older Younger
##   6.93202813993879e-10      0       0
##   4.35727481485329e-09      0       0
##   0.0434782608695653       23       0
##   0.222222222222222         0      45
##
## , , Sex = M
##
##                        AgeCategory
## probability.of.Data     Older Younger
##   6.93202813993879e-10      5       0
##   4.35727481485329e-09      0      14
##   0.0434782608695653        0       0
##   0.222222222222222         0       0
```

Read in the data - Younger animals only

```
YoungerData=read.csv("Younger.csv")
xtabs(~ Died_InTrt + Sex, data=YoungerData)
```

```
##           Sex
## Died_InTrt  F  M
##          0 36 14
##          1  9  0
```

Run a generalized linear model for sex in the dataframe only containing younger individuals

```
logistic3 <- glm(Died_InTrt ~ Sex, data=YoungerData, family="binomial")
summary(logistic3)
```

```
##
## Call:
## glm(formula = Died_InTrt ~ Sex, family = "binomial", data = YoungerData)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -0.66805  -0.66805  -0.66805  -0.00013   1.79412
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -1.3863     0.3727   -3.72 0.000199 ***
## SexM         -17.1798  1743.2485   -0.01 0.992137
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 50.397  on 58  degrees of freedom
## Residual deviance: 45.036  on 57  degrees of freedom
## AIC: 49.036
##
## Number of Fisher Scoring iterations: 17
```

```
Youngfemale.log.odds <- log(9 / 36)
Youngfemale.log.odds
```

```
## [1] -1.386294
```

```
Youngmale.log.odds <- log(0 / 18)
Youngmale.log.odds
```

```
## [1] -Inf
```

Now calculate the overall "Pseudo R-squared" and its p-value for younger individuals by sex

```
 ## NOTE: Since we are doing logistic regression...
## Null devaince = 2*(0 - LogLikelihood(null model))
##               = -2*LogLikihood(null model)
## Residual deviacne = 2*(0 - LogLikelihood(proposed model))
##                   = -2*LogLikelihood(proposed model)
ll.null <- logistic3$null.deviance/-2
ll.proposed <- logistic3$deviance/-2

## McFadden's Pseudo R^2 = [ LL(Null) - LL(Proposed) ] / LL(Null)
(ll.null - ll.proposed) / ll.null
```

```
## [1] 0.1063724
```

```
## chi-square value = 2*(LL(Proposed) - LL(Null))
## p-value = 1 - pchisq(chi-square value, df = 2-1)
1 - pchisq(2*(ll.proposed - ll.null), df=1)
```

```
## [1] 0.02059365
```

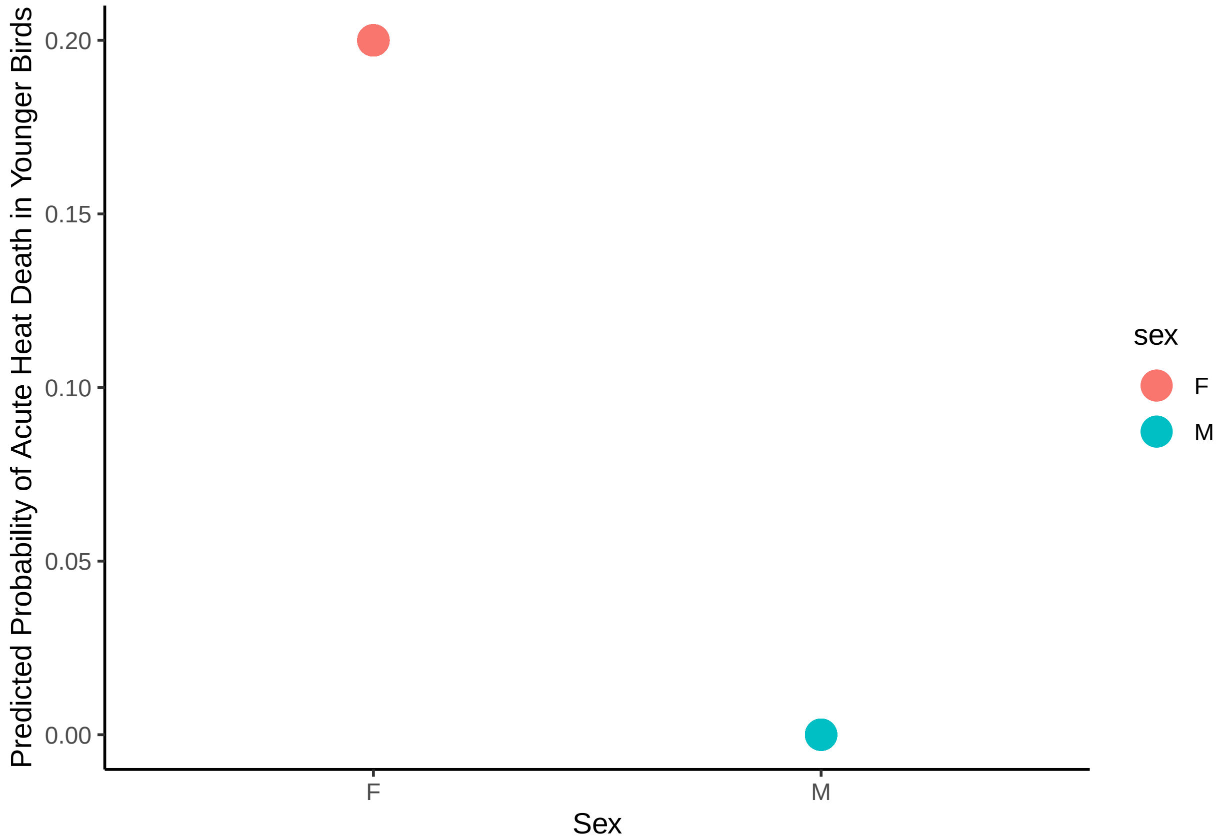
```
1 - pchisq((logistic3$null.deviance - logistic3$deviance), df=1)
```

```
## [1] 0.02059365
```

Lastly, let's see what this logistic regression predicts.

```
predicted.data <- data.frame(
  probability.of.YoungerData=logistic3$fitted.values,
  sex=YoungerData$Sex)

## We can plot the data...
ggplot(data=predicted.data, aes(x=sex, y=probability.of.YoungerData)) +
  geom_point(aes(color=sex), size=5) +
  xlab("Sex") +
  ylab("Predicted Probability of Acute Heat Death in Younger Birds") +
  theme_classic()
```




```r
## Since there are only two probabilities (one for females and one for males),
## we can use a table to summarize the predicted probabilities.
xtabs(~ probability.of.YoungerData + sex, data=predicted.data)
```

```
##                             sex
## probability.of.YoungerData   F  M
##        8.6468692450059e-09   0 14
##        0.2                  45  0
```